High-Voltage Thyristor Tube up to 1 MV and Controllable Rectifier Concept

LinkedIn-ready English publication draft

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Safety boundary: This is a conceptual R&D publication, not a construction guide. A 1 MV system is lethal and requires a certified high-voltage laboratory, grounded enclosure, interlocks, remote operation, partial-discharge testing, and a trained HV safety team.

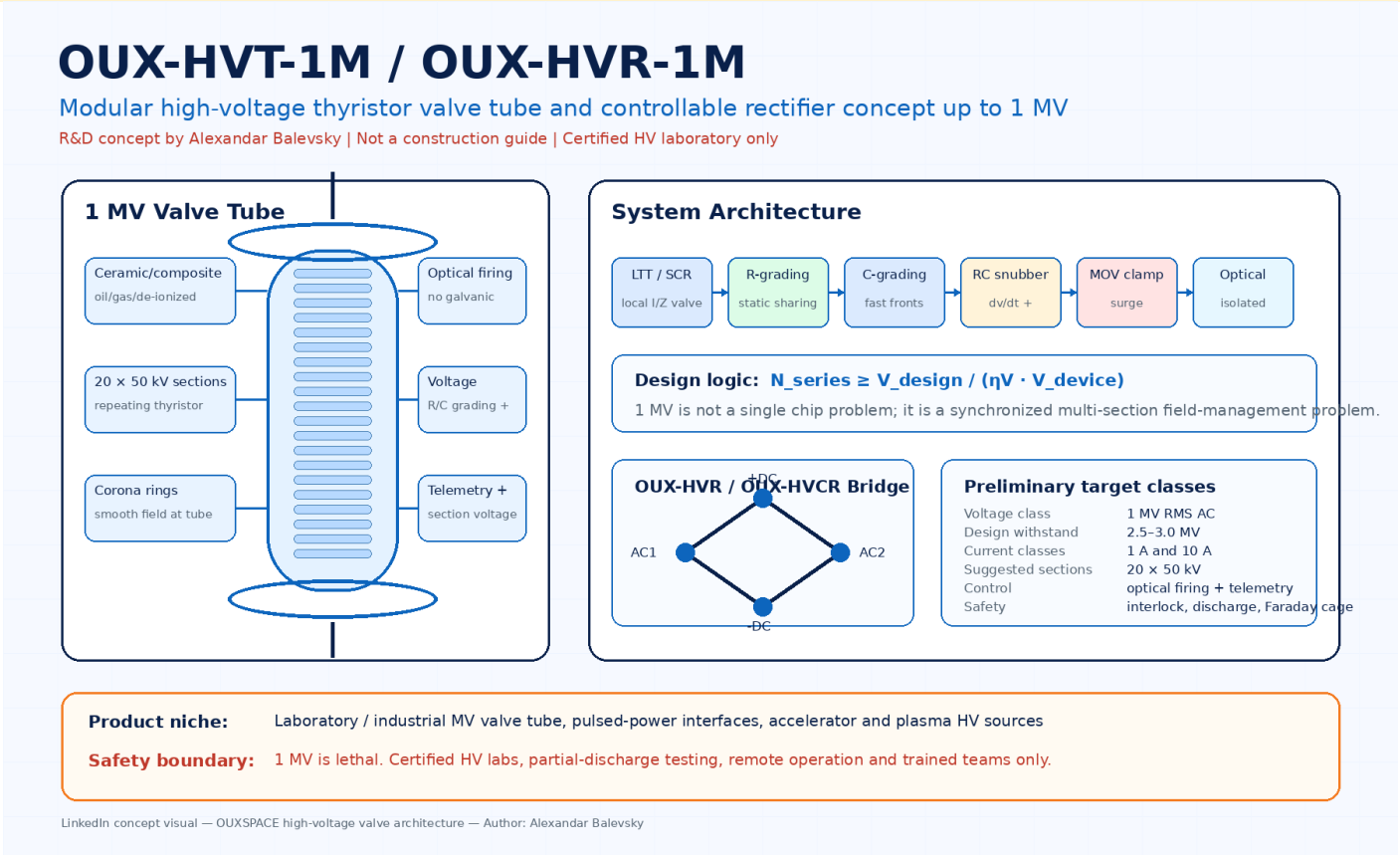
OUX-HVT-1M / OUX-HVR-1M
Modular high-voltage thyristor valve tube and controllable rectifier concept up to 1 MV
R&D concept by Alexandar Balevsky | Not a construction guide | Certified HV laboratory only
1 MV Valve Tube
Ceramic/composite
oil/gas/de-ionized
Optical firing
no galvanic
20 × 50 kV sections
repeating thyristor
Voltage
R/C grading +
Corona rings
smooth field at tube
Telemetry +
section voltage
System Architecture
LTT / SCR
local I/Z valve
R-grading
static sharing
C-grading
fast fronts
RC snubber
dv/dt +
MOV clamp
surge
Optical
isolated
Design logic: N_series ≥ V_design / (ηV · V_device)
1 MV is not a single chip problem; it is a synchronized multi-section field-management problem.
OUX-HVR / OUX-HVCR Bridge
+DC
AC1
AC2
-DC
Preliminary target classes
Voltage class 1 MV RMS AC
Design withstand 2.5–3.0 MV
Current classes 1 A and 10 A
Suggested sections 20 × 50 kV
Control optical firing + telemetry
Safety interlock, discharge, Faraday cage
Product niche: Laboratory / industrial MV valve tube, pulsed-power interfaces, accelerator and plasma HV sources
Safety boundary: 1 MV is lethal. Certified HV labs, partial-discharge testing, remote operation and trained teams only.
LinkedIn concept visual — OUXSPACE high-voltage valve architecture — Author: Alexandar Balevsky

Figure 1. LinkedIn concept visual for the OUX-HVT-1M modular high-voltage valve architecture.

LinkedIn post text

High-voltage power electronics should not be viewed only as bigger semiconductor chips. At the 1 MV level, the real engineering problem becomes field management, synchronization, insulation, thermal control, and safe diagnostics.
I am proposing the OUX-HVT-1M / OUX-HVR-1M family: a modular high-voltage thyristor valve tube and rectifier concept for laboratory and industrial megavolt-class applications. The core idea is not a single 1 MV device, but a synchronized stack of many derated valve levels with optical firing, R/C voltage grading, RC snubbers, MOV surge protection, corona-field shaping, telemetry, and an active insulating/cooling medium.
The goal is a compact modular product niche between small laboratory HV assemblies and full grid-scale HVDC valve halls: 1 MV RMS AC at the 1 A class, with a later 10 A class using parallel complete columns or power cells.
This is an R&D concept, not a construction guide. A 1 MV system is lethal and belongs only in certified high-voltage laboratories with remote operation, interlocks, discharge systems, partial-discharge testing, and trained teams.
#HighVoltage #PowerElectronics #Thyristor #HVDC #PulsedPower #IndustrialR&D #OUXSPACE #EngineeringDesign

1. Concept overview

The OUX-HVT-1M is proposed as a tubular high-voltage thyristor valve column for controlling alternating voltages up to the 1 MV RMS class. The related OUX-HVR and OUX-HVCR concepts extend the same architecture into passive and controllable rectifier bridges.

The core engineering principle is simple: 1 MV should not be implemented as a single semiconductor element. A realistic design path uses a multi-section tube containing many series-connected valve levels, optical triggers, R/C grading, RC snubbers, MOV clamps, corona rings, telemetry, and an active insulating/cooling medium.

In the OUXSPACE interpretation, each thyristor level acts as a local I/Z phase valve. The complete tube is a synchronized phase column intended to reduce unwanted losses into heat, corona, and parasitic paths through geometry, alignment, and section-level feedback.

2. Basic scaling logic

For a series high-voltage valve stack, the minimum number of levels follows the first-order design relation:

$N_{series} \geq V_{design} / (\eta V \cdot V_{device})$

where N_{series} is the number of series levels, V_{design} is the required design withstand voltage, ηV is the derating factor, and V_{device} is the nominal voltage class of a single valve level.

At 1 MV RMS AC the peak voltage is about 1.414 MV. With a design margin of roughly 1.8–2.2×, the target insulation withstand range becomes approximately 2.5–3.1 MV. With 8 kV-class thyristors and 50% derating, an individual level carries about 4 kV, so a full design may require several hundred levels per direction.

3. Proposed device family

Model	Function	Nominal class	Current	Suggested realization
OUX-HVT-1M-1A	AC thyristor tube	1 MV RMS AC	1 A	Two antiparallel thyristor columns
OUX-HVT-1M-10A	High-power AC tube	1 MV RMS AC	10 A	Power cells or parallel complete columns
OUX-HVT-PAR	Parallel module	1 MV class	N×1 A / N×10 A	Parallel full columns with ballast and feedback
OUX-HVR-1M-1A	Passive rectifier	1 MV AC → DC	1 A	Four diode HV columns in a bridge
OUX-HVCR-1M-1A	Controlled rectifier	1 MV AC → controlled DC	1 A	Four thyristor HV columns
OUX-HVCR-1M-10A	Controlled power rectifier	1 MV class	10 A	Cooled parallel bridge columns

4. One repeating OUX-HVTL cell

Each level contains a thyristor or light-triggered thyristor, static R-grading, dynamic C-grading, RC snubber, MOV surge clamp, optical trigger receiver, and optical telemetry. This is necessary because a series stack of hundreds of levels will never share voltage perfectly without active and passive equalization.

$$V_i = V_{total}/N + \Delta V_{static} + \Delta V_{dynamic} + \Delta V_{stray}$$

The practical design goal is to keep ΔVstatic, ΔVdynamic, and ΔVstray small through matched sections, symmetric geometry, snubbers, grading networks, and parasitic-capacitance control.

5. Rectifier and controlled rectifier

OUX-HVR-1M is a diode Graetz bridge built from four HV columns. OUX-HVCR-1M replaces the diode columns with thyristor columns and enables controlled DC output by phase angle. In the controllable version, the average DC voltage is regulated electronically rather than through mechanical switching.

For a 1 MV RMS AC input, each bridge arm must withstand the required reverse/design voltage with a practical margin, especially under transient overvoltage conditions.

6. Position relative to existing HVDC practice

The concept is not presented as a replacement for grid-scale HVDC converter stations. Those systems are optimized for large energy transmission infrastructure. The proposed product niche is different: a specialized modular megavolt valve tube for laboratory, industrial, accelerator, plasma, and high-voltage source applications in the 1–10 A class.

The concept borrows proven architectural principles from HVDC valve practice—series levels, grading networks, snubbers, optical firing, cooling, and redundancy—but repackages them into a tubular modular column rather than a full valve hall.

7. Preliminary parameters

Parameter	OUX-HVT-1M-1A	OUX-HVT-1M-10A	Comment
AC voltage	1 MV RMS	1 MV RMS	Peak is about 1.414 MV
Design insulation	2.5–3.0 MV	2.5–3.0 MV	Margin for impulses, corona,

			and non-uniformity
Current	1 A	10 A	The 10 A version requires stronger thermal architecture
Load power class	~1 MW	~10 MW	This is load power, not loss power
Levels at 8 kV class	~650–750 per direction	~650–750 per direction	Current class changes thermal design, not voltage count
Sections	20 × 50 kV	20 × 50 kV	Simplifies service and diagnostics
Control	Optical	Optical + current sharing	No galvanic control connection
Cooling	Oil / gas / de-ionized water	Active liquid cooling	The 10 A class is thermally harder
Safety	Interlock + discharge + Faraday cage	Same + thermal trip	Mandatory

8. Staged prototyping roadmap

Stage	Goal	Voltage / current	Success criterion
P1	Single cell	5–10 kV, 0.1 A	Trigger, snubber, leakage, thermal stability
P2	Single section	50 kV, 0.1–1 A	Uniform voltage distribution, partial-discharge below threshold
P3	Two sections	100 kV, 1 A	Synchronous firing and AC control
P4	Demo tube	250–500 kV, 1 A	Corona, cooling, telemetry, fault bypass
P5	Full system	1 MV, 1 A	Certified laboratory demonstration
P6	Power version	1 MV, 10 A	Parallel columns or power-cell current sharing

9. Main risks and protection layers

Partial discharge / corona: smooth field shaping, corona rings, insulating medium, PD testing.

Uneven voltage distribution: R/C grading, snubbers, matched sections.

False trigger from dv/dt or noise: RC snubbers, optical firing, shielding, correct grounding.

Thermal runaway: temperature sensors, derating, active coolant.

Parallel imbalance: ballast, complete-column paralleling, optical current feedback.

Operator hazard: remote operation, interlocks, grounding, discharge system, Faraday cage.

10. Conclusion

OUX-HVT-1M is a plausible R&D direction for a new high-voltage product niche: not a grid-scale HVDC station, but a specialized tubular valve column for laboratory and industrial megavolt-class sources at 1–10 A. The concept is compatible with established high-voltage valve practice while adding an OUXSPACE phase-valve interpretation and a modular tube format.

Editorial note: This English version is translated and condensed for LinkedIn from the Bulgarian technical report. Public reference anchors from the source document may be retained in a longer technical white paper, but the LinkedIn version intentionally avoids construction-level details.